Code: 9A19401

1

II B. Tech II Semester (R09) Regular Examinations, April/May 2012

CONTROL SYSTEMS

(Electronics & Computer Engineering)

Time: 3 hours Max Marks: 70

Answer any FIVE questions

All questions carry equal marks

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1 (a) Explain the classification of control systems with examples.

(b) Find the transfer function $\frac{\theta(s)}{T(s)}$ for the following system shown in figure 1.

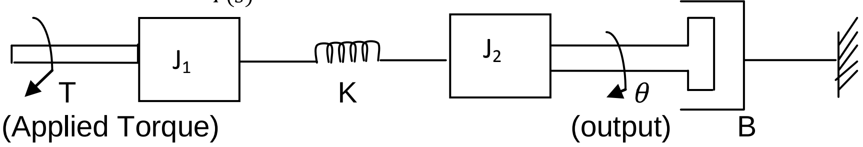

Figure 1

2 (a) Draw the connection diagram of Synchro pair used as a position indicator.

(b) Draw the signal flow graph for the system of equations given below and obtain the overall transfer function using Mason's rule:

$X_2 = X_1 – X_6$

$X_3 = G_1X_2\text{-}H_2X_4\text{-}H_3X_5$

$X_4 = G_2X_3\text{-}H_4G_6$

$X_5 = G_5X_4$

$X_6 = G_4X_5$

3 (a) Derive the static error constants and list the disadvantages.

(b) A unit feedback system is characterized by an open-loop transfer function G (s) $=\frac{K}{S(S+5)}$. Determine the gain K so that the system will have a damping ratio of 0.5. For this value of K determine settling time, peak overshoot and times to peak overshoot for a unit-step input.

4 (a) How the roots of the characteristic equation are related to stability?

(b) The open loop transfer function of negative unity feedback system is given by G (s) $=\frac{K}{S(S^2+6s+10)}$. Sketch the root locus for K > 0. Determine the range of K for which the system is stable. Also find the value of K for which the system oscillates and frequency of oscillation.

5 (a) Explain the correlation between time and frequency response of a system.

(b) Explain the frequency response specifications.

6 (a) Draw & explain polar plots for type – 0, type -1 & type – 2 systems.

(b) Write a note on relation between root loci & Nyquist plots.

Contd. in Page 2

Code: 9A19401

1

7 A unity feedback system has an open loop transfer function G (s) $=\frac{K}{S(1+2s)}$. Design a suitable log compensator so that phase margin is 40^0 and the steady error for ramp input is less than or equal to 0.2.

8 (a) Consider the network shown in figure 2 and obtain the state variable form:

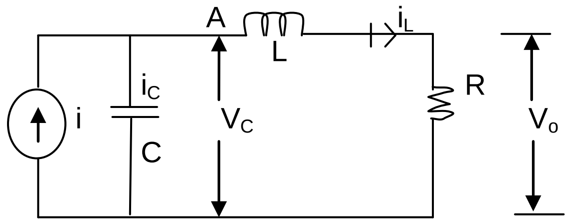

Figure 2

(b) Explain properties and significance of state transition matrix.

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2

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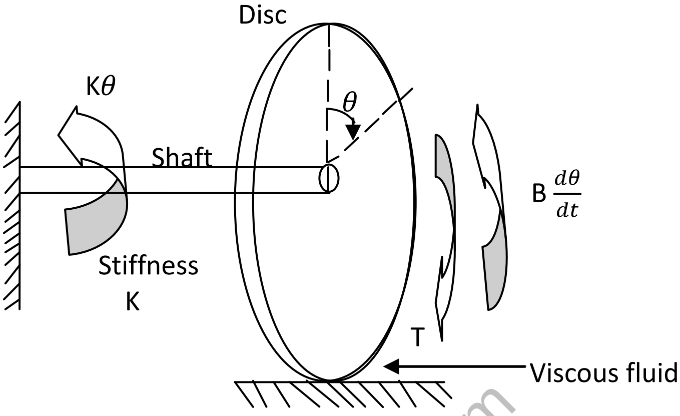
1 (a) Explain the difference between open loop and closed loop systems.
(b) Derive the transfer function for the following rotational mechanical systems shown in figure1



Rotational
Figure 1

2 (a) Explain the need of Mason's gain formula for any system reduction.
(b) Obtain the transfer function of $\frac{E_o(s)}{E_i(s)}$ of the electrical network shown in figure 2

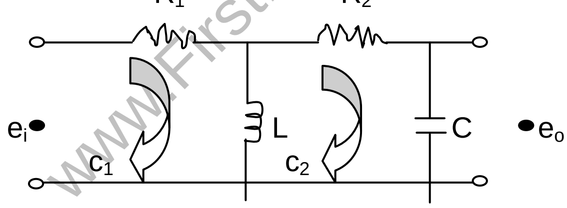


figure 2

3 (a) Explain error constants K_p, K_v, K_a for type -1 system.
(b) The open loop transfer of a unity feedback control system is given by G (s) $=\frac{K}{S(TS+1)}$ where K and T are positive constants. By what factor should the amplifier gain be reduced so that the peak overshoot of unit step of the system is reduced from 75% to 25%.

Contd. in page 2

4 (a) A unity feedback control system is characterized by the open-loop transfer function $G(s) = \frac{K(s+13)}{S(s+3)(S+7)}$.

(i) Using the Routh's criterion, determine the range of values of K for the system to be stable.

(ii) Check if for K = 1, all the roots of the characteristic equation of the above system have damping factor greater than 0.5.

(b) Calculate the values of K and for the point in S-plane at which the root locus of $G(s)\,H(s) = \frac{K}{S(S+2)(S^2+2s+2)}$ intersects the imaginary axis.

5 Draw the bode plots and find the gain margin and phase margin of a system represented by $G(s)\,H(s) = \frac{10\,(s+1)}{S(S+0.05)(s+3)(s+5)}$

6 What is Nyquist path? Plot Nyquist stability for $G(s)H(s) = \frac{20}{s(1+0.1s)(1+0.5s)}$

7 For the unity feedback control system forward path transfer function $G(s) = \frac{K}{S(S+4)(S+20)}$. Design a lag-lead compensator so that PM $\geq 40^0$ and steady state error for unit ramp input $\leq$ 0.04 rad.

8 (a) Define state, state variable and explain the significance of state variable analysis.

(b) A system is described by:

$$\dot{\text{I}} = \begin{bmatrix} -1 & -4 & -1 \\ -1 & -6 & -2 \\ -1 & -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix} u.$$

$$y = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Find the transfer function and construct the signal flow graph.

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3

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1 (a) What is feedback? Explain the effect of feedback on stability.

(b) Obtain the transfer functions $\frac{X_1(s)}{U(s)}$ and $\frac{X_2(s)}{U(s)}$ of the mechanical system shown in figure 1

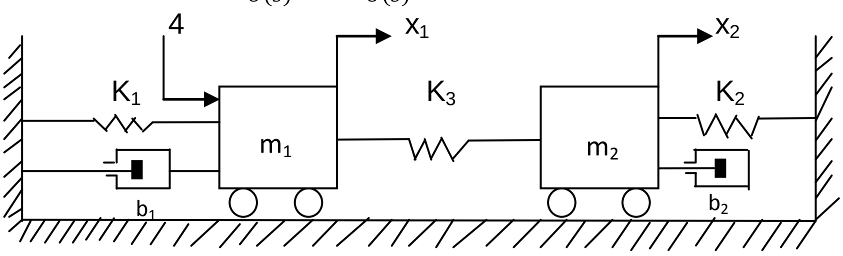

Figure 1

2 (a) Explain the differences between AC servomotor and DC servomotor.

(b) Determine the transfer function C(s)/ R(s) for the following block diagram (figure 2)

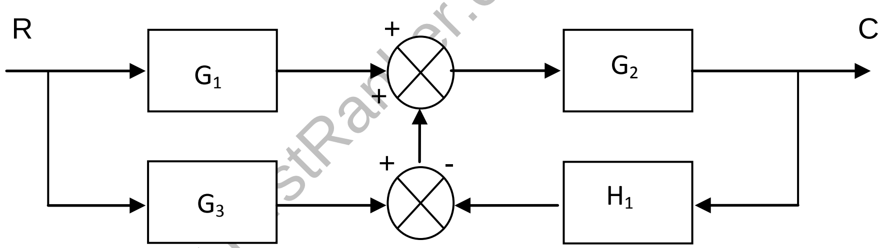

Figure 2

3 (a) Define time constant and explain its importance.

(b) For a negative feedback control system having forward path transfer function: $G(s) = \frac{K}{s(s+6)}$ and H(s) = 1, determine the value of gain K for the system to have damping ratio of 0.8. For this value of gain K, determine the complete time response specifications.

4 (a) Define the terms: (i) Absolute stability (ii) Marginal stability (iii) Conditional stability.

(b) Plot the root loci for the closed loop control system with $G(s) = \frac{K}{S(S+1)(S^2+4s+5)}$ H(s) = 1.

5 (a) Show that in bode magnitude plot the slope corresponding to a quadratic factor is -40 dB/dec.

(b) Explain with the help of examples: (i) Minimum phase function (ii) Non minimum phase function (iii) All pass function.

Contd. in Page 2

Code: 9A19401

3

6 (a) Explain Nyquist stability criterion.

(b) A unity feedback control system has an open loop transfer function given by $G(s)\,H(s)=\frac{100}{(s+5)(s+2)}$. Draw the Nyquist diagram and determine its stability.

7 For $G(S) = \frac{K}{S(S+2)(S+20)}$. Design a lag compensator given phase margin $\geq 35^0$ and $K_v \leq 20$.

8 Write the state equations of the system shown in figure 3 in which X_1, X_2 and X_3 constitute the state vector. Determine whether the system is completely controllable and observable.

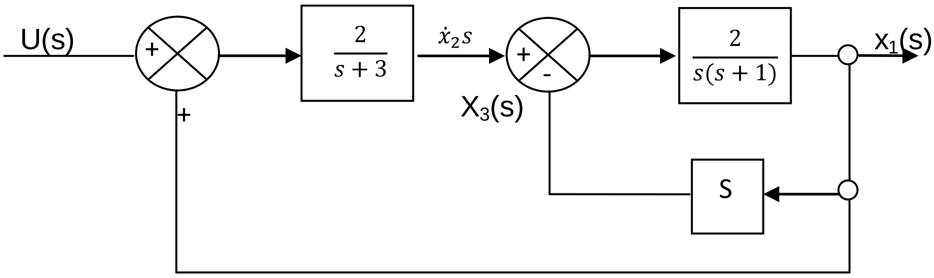

Figure 3

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Code: 9A19401

4

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1 (a) Explain with example, the use of control system concepts to engineering and non engineering fields.

(b) For the mechanical system figure 1 given, write down the differential equations of motion and hence determine the $\frac{y_2(s)}{F(s)}$.

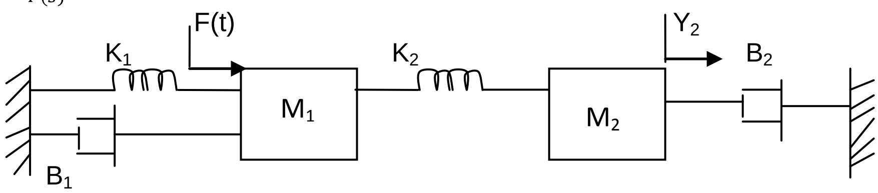

Figure 1

2 (a) Derive the transfer function for the field controlled d.c. servomotor with neat sketch.

(b) Explain the advantages and features of transfer function.

3 (a) Derive the time response of second order under damped system due to unit step input.

(b) The unit step response of a second order linear system with zero initial state is given by c(t) = $1+1.25\ e^{-6t}(\sin 8\ t-\tan^{-1} 1.333)$. Determine the damping ratio, undamped natural frequency of oscillations and peak overshoot.

4 (a) Show that the Routh's stability criterion and Hurwitz stability criterion are equivalent.

(b) Draw the root locus diagram for a feedback system with open-loop transfer function $G(s) = \frac{K\,(S+5)}{S(S+3)}$ following systematically the rules for the construction of root locus. Show that the root locus in the complex plane is a circle.

5 (a) Define bandwidth and derive the expression for the bandwidth of a second order system.

(b) Bring out the correlation between time response & frequency response and hence show that the correlation exists for the range of damping ration $0<\zeta<0.707$.

6 The open loop transfer function of a unity feedback control system is $G(s) = \frac{10}{S(S+1)(S+5)}$. Draw its polar plot and hence determine its phase margin and gain margin.

7 The uncompensated open loop transfer function of a unity feedback system is $G(s) = \frac{K}{S(1+0.5s)}$. Design a phase-lead compensator to meet the specifications: (i) For a unit ramp-input the steady state error should be less than or equal to 0.1 units. (ii) Phase margin of the system be greater than 40^0.

8 (a) Define controllability and observability.

(b) Consider now that the system has forcing function and is represented by the following non homogeneous state equation $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}1 & 0\\ 1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}1\\ 0\end{bmatrix}u$ where u is the step function. Compute the solution of this equation assuming the initial state vector is $x_0 = \begin{bmatrix}1\\ 0\end{bmatrix}$.

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